Analyze of Image Quality Parameters on Laser Printouts as Proposal to Extension Standard ISO 13660

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Abstract

Standard ISO13660, which presents mainly parameters of mono- chrome printouts, has a few shortcomings. They are connected with lack of quality control for color printouts as well as subjective customer feelings not taken into account.

Recently technologies of digital printing have been developing very fast and because of that they are not only very varied, but what is more important they have different features.

Analyzing different technologies of printing it is possible to say what kind of characteristics is common for each technology.

After theoretical analysis as well as own works there were proposed extension of norm ISO13660 (as part 2). In the part there were presented important parameters of printouts for laser technology.

This work deals with parameters of IQ of laser printouts, especially color graphics images.

In this work there are proposed parameters and methodology of measurement, the method of special control printouts (test charts) is evolved, and conclusion after making scientific research are taken.

Introduction

Electrostatic phenomena prevailing in the case of laser technique of digital printing influence in a large measure the quality of the laser printouts. Fast development of the technique of electrostatic printing, especially color laser printing, justifies numerous researches concerning evaluation of the image quality of laser printouts and necessity of unequivocal and quantitative determining values of the parameters characterizing the image quality of the printouts, which is one of the most important parameters for evaluating laser printers.

Fast development of their design, their mass production as well as marketing reasons stimulate a necessity of an accurate definition and unequivocal measurement of parameters of image quality as well as development of international standardization works in this field. A basic standard concerning the image quality is the standard ISO 13660[1] that defines the main parameters of image quality, a way of measuring them, and provides test control printouts for some of the defined parameters.

Because the standard reveals many shortcomings, it is purposeful to carry out research and standardization works aimed to extend the standard and make it more accurate. It is also advisable to revise it and to supplement it with part standards concerning image quality of printouts obtained by means of particular techniques of digital printing.

The main shortcomings of the standard ISO 13660 are:
- lack of parameters characterizing image quality of color printouts,
- lack of an accurate definition of standards for test printouts that allow for a measurement of all the defined parameters,
- lack of referring to subjective perception feelings of the reader (yet, every printout is intended for reading),
- lack of definition of ways of calibrating the printer making the test printout as well as calibrating devices used during the measurements (scanner, monitor),
- lack of definition of quality parameters specific for particular printing technique.

Therefore, it is proposed to revise the standard ISO 13660.[5,6] Because of specific features of the technique of laser printing, it is purposeful to extend the standard ISO by a part standard regarding specific features of laser printouts.

Analysis of the Influence of Print Technology, Mechanisms of Laser Printers on the Image Quality

The following features characterize the technique of laser printing:
- predominance of electrostatic phenomena taking place in almost all the stages of the printing cycle of the laser printer,
- use of a dye in the form of a toner, fast development of the technology for manufacturing toners (introduction of toners manufactured by emulsion aggregation - EA),

- lower (compare to the ink-jet printing) influence of the paper properties, possibility of printing on a paper having more differentiated parameters,
- fast development of printing mechanisms of laser printers (replacing the four-pass printing with single-pass printing, and improving quality of the units of laser printers),
- many years of tradition in designing mechanisms of laser printers, mastering and verification of the technological processes related to laser printing,
- importance of the systems for color control and management having significant influence on the image quality of laser printing.

Effect of the electrostatic phenomena in laser printing is evident while charging the semiconductor surface of the printing drum with an electrostatic charge, during imputing information to be printed, by means of a laser beam that discharges this surface, during electrostatic transfer of the dye from the cartridge onto the drum, during transfer of the dye onto the intermediate tape and then onto the paper.

In the case of laser printing, the electrostatic phenomena determine:
- quantity of the toner transferred onto the paper, so color saturation and darkness of the printed image,
- precision of placing the toner particles – this way they influence quality parameters of the edge of the printed image (e.g. raggedness), mutual position of the toner particles of the particular primary colors, and thus the hue,
- correctness of the fill and the mottle of the image.

Influence of the toner on the image quality results from many of its properties:
- fineness of the toner particles and homogeneity of their dimensions – they determine correctness of the processes related to their electrostatic transfer in the successive stages of printing, and thus influence the image quality[2-4]
- as far as the modern toners are concerned, much smaller dimensions of the particles (of about 5 μm compare to those previously used of about 9μm) allow for printing with an increased density (e.g. 1200 dpi)[3] and making copies consisting of small points that faithfully reproduce details of the original images.
- susceptibility of the toner particles to its tribo-charging and high ratio of the charge to the mass of the toner particles (q/m) influence in a large measure saturation of the printed image – it influences the parameter of darkness,
- physiochemical properties of the toner determining adherence of the particles to the printing drum and the paper, influencing the process of its transferring and fusing, what results in blurriness of the edges of the printed images and saturation. Physical properties of the toner determine also resistance of the printouts to exposure to UV radiation and humidity. Their influence on the image quality appears after long periods of time and results in fading of the printouts (decreasing the parameter of darkness). However, these influences are much smaller in the case of the ink-jet printouts.

Influence of the paper on the image quality of laser printouts is revealed mainly by its electrostatic properties (playing an important role while transferring the dye from the printing drum unto the paper and while fusing the dye).

Introduction of new, highly glazed papers for laser printing significantly improved conditions of depositing and fusing the toner on the paper, and thus improved quality of the printouts – they are more homogeneous as far as the color is concerned, their edges are less fuzzy, color saturation is better.

Design units of the printing mechanism of a laser printer influence many parameters of the image quality. For instance, optical and mechanical errors of the unit transmitting the laser beam result in changes of intensity of discharging the drum surface, and as a consequence, changes of coloring of the printed image (influence on the following parameters: darkness, fill, mottle). Replacing the traditional corona electrodes, having a form of a pan and a wire, with rotational contact roll units that deposit the electrostatic charges, improved the process of charging and made the generated electrostatic field more uniform. Eccentricity of the printing drum as well as imprecise operation of the fuser causes banding. Lack of synchronization of the rotational speed of the drum with the speed of paper feeding results in a significant blurriness on the edges of the outline of the printed image. The applied system of controlling the printing process and color management system - CMS are of a great importance. They influence the parameters of image quality of both monochromatic as well as color printings[5,6] In the of high quality color printers, it is very important to match up high resolution of the printing, small dimensions of the printed spot with resolution of the source files, and to match up the precise localization of the printed points with performance of the unit controlling operation of the printer and with the color management system. Most of the manufacturers of the laser printers apply their own systems of controlling and improving quality of the printouts.

For instance, Hewlett Packard introduced a dynamic control of the voltage at the electrodes charging the surface of the printing drum, as the semiconductor layer of the drum wears and degenerates. That makes the image quality more uniform, no matter how long the printer is used, and keeps it on the same level. The Xerox Company introduced a new generation of emulsion aggregation toners, based on a technology of emulsion aggregation that ensures very fine and homogeneous particles of the toner[2-4] what significantly improves the process of laser printing and the relevant image quality - Fig.1 This technology improves also quality of color image. It is achieved by equalizing features of the toners of all the dyes of the primary colors (the toners that have been applied before, fabricated by means of milling and dimension segregation of the dye particles, featured various dimensions and properties – e.g. particles of the yellow toner were much smaller compare to those of the other primary colors.

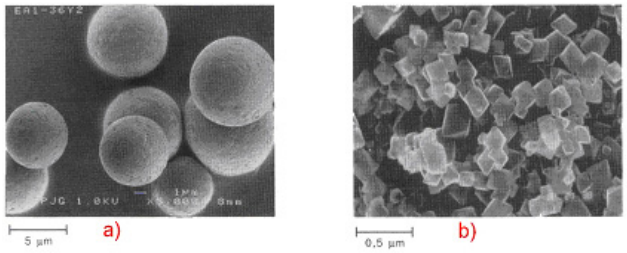

Figure 1.[3] *EA toners - comparison of the particles a) of EA toners, b) of traditional toners*

As far as the image quality of color laser printers is concerned, it is very important to match the electronic image source files with the system of color management and the system of printer control. Resolution and format of the file must match the systems. In the case of color laser printers it is common to use 6 or 7 primary colors (these are extended methods of representing the CMYK basic colors). The source files obtained by scanning and processing the original images usually comply with RGB (or sRGB) system. Therefore, in the case of high quality laser printers it is necessary to use a color management system and a special raster image processor (RIP) that synchronizes the way of representing and printing the color image. Conversions from the RGB to CMYK system, realized by means of the parameters of the Lab system (a system of color representation not dependent on the hardware) and application of ICC color profiles, must ensure matching of the printed image to the color parameters of the source file. Each mismatch and deviation of the color parameters result in decreasing quality of the colors of the printed image. They cause the moire effect, mottle and hue of the colors of the printed images. A correct reproduction of the colors is even more complicated because of the fact that there is a lack of international standards concerning color standards and systems converting the RGB parameters into Lab and CMYK parameters. There are carried out intense research and standardization works aimed to determine these basic elements of representing and reproducing colors.

Parameters of the quality of color image are not standardized either, being at the same time very important for evaluation of the image quality of laser printouts. While working on them, it is important not only to specify definition of the parameters in an objective and correct way, but also to make sure that these parameters can be measured by a user in an easy and available way. There should be also taken into account that the printed images are intended to be read and looked at by a human eye. So, there must be introduced some factors that give consideration to a subjective evaluation of the image quality by the reader. Because the human eye analyses image using the RGB system and also input files for printing use this system, while choosing a method for determining the quality of color image, it is logical to base the evaluation of the image quality on color analysis employing color representation in RGB system.

Accuracy of reproducing a color is important here, therefore, as the basic parameter of the quality of color images, it is proposed to determine difference between the color of the printed image and the standards of the primary colors defined beforehand (the international standardization commissions work on this problem). Such difference can be easily described and measured using a spectrophotometer (e.g. while carrying out a research there was used a SPECTROLINO spectrophotometer by Gratag Macbeth). Correctness of the measurement can be checked using the method accepted in the standard ISO/IEC 13660, by measuring certain parameter of the image quality of one precisely made standard of a printout and then comparing results of the measurements w the results, and their deviations, provided in the standard. Reasoning this way, it is proposed to accept as a basic parameter of the color quality "fidelity of reproducing a primary color in areas with 100% saturation of the primary RGB color, and measured as ΔE_{Lab}". In order to take into account the subjectivity in evaluation of color quality it is proposed to make printouts of stripes of the primary colors whose saturation successively increases form 0 to 100% by 10% or in a 16-grade scale, according to the standard DIN 8366 terwards, it is proposed to measure differences of the saturation in the adjoining areas. Then, larger differences of the colors in the adjoining areas are a better result – the observer's eye will be able to better distinguish between them.

Analysis of the value of the saturation of RGB colors may be carried out in various ways. The most simple is to measure the parameter of darkness, defined in the standard ISO/IEC 13660 for black-and-white printings and measured e.g. at an area with 100% saturation of a given primary color. Results of such measurements performed within a research are presented in Tab. 1 for printings made by different laser printers.

Table 1. Results of Measurements of the Parameter of Darkness in Case of Printings with 100% Saturation Made by different Laser Printers

Printer	Darkness (75%M, 75%Y)	
	Average	St. Dev
P1	84,39	0,20
P2	84,39	0,20
P3	83,82	0,22

There was carried out a research, where for instance measurements of saturation of the primary colors were performed in a different way. Regions with 75M+75Y saturation of the CMYK colors were scanned, and then there were determined histograms representing number o pixels in the output file having certain saturation. Afterwards, value of the weighted average of an equivalent saturation was calculated.

The equivalent saturation was calculated according to the formula:

$H_{av} = [L_i H_i / L_i]$

where:

H_{av} – equivalent saturation

L_i – number of pixels having defined saturation "i"

H_i – successive value of the saturation "i"

Another method of comparing color saturation may be a method of spectral analyzing printouts of the primary colors (printing the areas of primary colors, analysis of the spectral curves of the RGB colors and their comparison by means of statistical methods). This method will be tested in a further research.

An important parameter for comparing image quality of color printouts is also a parameter of mottle, defined in the standard ISO/IEC 13660. It characterizes homogeneity of the color of the printed areas of the primary colors. These areas observed under the microscope – Fig. 2, clearly indicate that printouts made by different laser printers vary, especially in color saturation and distribution of particular color points.

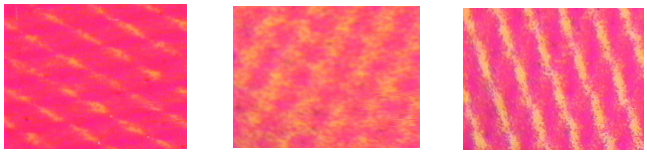

Figure 2. Microscope pictures of the test areas of color laser printings made by different printers.

The differences result from various methods of raster processing, different properties of the toners and the applied paper. The parameter of mottle characterizes these differences – Table 2.

Table 2. Parameter Value of Mottle for Color Printouts Made by Different Laser Printers

Printer	Mottle (75%M, 75%Y)	
	Average	St. Dev
P1	0,83	0,08
P2	0,81	0,09
P3	0,83	0,07

Conclusions

It may be stated that influence of the applied technique, toners, paper, methods of analyzing colors and controlling the printer operation on the image quality of laser printouts, especially color printouts, are interdependent and very complicated.

Analysis of these influences allowed us to single out few specific parameters of the image quality of laser printouts. These are: banding, mottle and the proposed parameters of color printings: darkness for the RGB primary colors, fidelity of reproducing a color ΔE_{Lab}, saturation of a color represented e.g. by an average saturation measured on the basis of comparison of histograms of the RGB primary colors.

Additional general parameters of the image quality of laser printouts may be the regular parameters (defined in the standard ISO/IEC): blurriness, raggedness, line width, fill.

It is purposeful to carry out further research and standardization works concerning image quality, especially parameters of color printings. So, it is advisable to revise the standard ISO/IEC 13660 and elaborate a detailed part standard referring to image quality of color laser printouts.

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Biographies

Ludwik Buczynski received his PH DR degree in micromechanics from Warsaw University of Technology in 1972. Since 1963 he worked in Micromechanics and Photonics Institute of Warsaw University of Technology and since 1986 to 2003 in R&D Center Office technique PREBOT Radom Poland. He is member of IS&T. Since 1990 his main area of interest are computer peripheral's devices and image quality investigations.

Adam Bieniewski is a student of Warsaw University of Technology, Institute of Micromechasnics and Photonics. His diploma work concern influence of laser print technology on quality of printout's and standardization of image quality.